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IS 11758 (1994): Precipitation hardening stainless steel castings [MTD 14: Foundry]



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अवक्षेपन कठोरता, स्टेनलैस इस्पात ढलाइयाँ — विशिष्ट

(पहला पुनरीक्षण)

Indian Standard

PRECIPITATION HARDENING STAINLESS
STEEL CASTINGS — SPECIFICATION

(First Revision)

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Steel Castings Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1986. While reviewing the standard in the light of the experience gained during these years, the committee has decided that the standard may be further revised. In this revision various clauses have been aligned with the recent standards on steel castings including modification in the requirement of gauge length and dimension 'R' of the test piece.

Precipitation hardening stainless steel castings are used in services requiring corrosion resistance and high strengths at temperatures up to 315°C. These castings may be machined in the solution annealed condition and subsequently precipitation hardened to the desired high strength mechanical properties specified in Table 3 with little danger of cracking or distortion. These castings are not intended for use in the solution annealed condition. If the service environment in which these are to be used is considered conducive to stress corrosion cracking, precipitation hardening should be performed at a temperature that will minimize the susceptibility of the castings to this type of attack.

In the formulation of this standard, assistance has been derived from the following publications:

- a) ASTM A 747/A 747 M-89 Specification for steel casting, stainless and precipitation hardening issued by the American Society for Testing and Materials.
- b) AMS 5355 C77 Specification for steel castings. Investment Corrosion Resistance 16 Cr—4.1 Ni — 0.28 (Cb + Ta) — 3.2 Cu. Aerospace Material Specification, USA.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (revised)'. The number of significant places retained in the rounded off value should be same as that of the specified value in this standard.

Indian Standard

PRECIPITATION HARDENING STAINLESS STEEL CASTINGS — SPECIFICATION

(First Revision)

1 SCOPE

This standard covers the requirements for precipitation hardening stainless steel castings.

2 REFERENCES

The Indian Standards listed in Annex A are necessary adjuncts to this standard.

3 TERMINOLOGY

3.1 For the purpose of this standard, the following definitions shall apply.

3.1.1 Cast (Melt)

The product of any of the following:

- a) One furnace heat,
- b) One crucible heat, or
- c) A number of furnace or crucible heats of similar composition mixed in a ladle or tapped in separate ladles and poured simultaneously for making a casting.

3.1.2 Batch

A group of castings of one grade of material, cast from the same melt and heat-treated together under identical conditions.

4 GRADES

This standard covers a total of two grades of precipitation hardening stainless steel castings.

5 SUPPLY OF MATERIAL

General requirements relating to supply of steel castings shall be as laid down in IS 8800 : 1986 and in case of investing casting to IS 11709 : 1986.

6 MANUFACTURE

The steel for the castings shall be made by electric arc or electric induction or such other processes as may be agreed to between the purchaser and the manufacturer.

7 PARTICULARS TO BE SPECIFIED WHILE ORDERING

For the benefit of the purchaser, particulars to be specified while ordering for steel castings to this specification are given in Annex B.

8 CHEMICAL COMPOSITION

8.1 The ladle analysis of steel when carried out either by the method specified in IS 228 and its relevant parts or any other established instrumental/chemical methods shall be as given in Table 1. In case of dispute the procedure given in IS 228 shall be the referee method. However, where the method is not given in IS 228, the referee method shall be as agreed to between the purchaser and the manufacturer.

**Table 1 Chemical Composition of Precipitation
Hardening Stainless Steel Castings**

Constituent	Requirement, Percent*	
	Grade 1	Grade 2
Carbon	0.07	0.07
Silicon	1.00	1.00
Manganese	0.70	0.70
Sulphur	0.030	0.030
Phosphorus	0.035	0.035
Chromium	15.50-17.70	14.0-15.50
Nickel	3.60-4.60	4.50-5.50
Copper	2.50-3.20	2.50-3.20
Niobium	0.15-0.35	0.15-0.35

*Maximum, unless range is specified.

8.2 The manufacturer shall carry out analysis from a sample of each melt of steel and, if so specified by the purchaser at the time of enquiry and order, shall supply a test certificate of chemical analysis of the sample of steel for each melt.

8.3 Product Analysis

If specified at the time of enquiry and order, the product analysis may be carried out from a test piece or from a casting representing each melt. Drillings for analysis shall be taken from not less than 6 mm beneath the cast surface, and in such a manner as not to impair the usefulness of any casting selected. The permissible variation in product analysis from the limits specified in Table 1 shall be as given in IS 6601 : 1987.

8.4 Residual Elements

8.4.1 Elements not specified in Table 1 shall not ordinarily be added to the steel and all reasonable precautions shall be taken to prevent contamination from scrap, etc, to keep them as low as practicable.

8.4.2 The following limits shall apply for the elements not specified in Table 1:

Constituent	Percent, Max
Nitrogen	0.05

8.4.3 Analysis and reporting of the analysis in the test certificate for the above residual element shall be done only when so specified by the purchaser in the enquiry and order. However, the manufacturer shall ensure that the residual elements are within the limits specified.

8.4.4 When the supply is in T 480 condition (see Table 2) the lower limits of Niobium content shown above shall not apply.

9 WORKMANSHIP AND FINISH

9.1 The castings shall be accurately moulded in accordance with the pattern or the working drawings supplied by the purchaser with the addition of such letters, figures and marks as may be specified.

9.2 The purchaser shall specify the tolerances on all important dimensions. On other dimensions, tolerances specified in IS 4897 : 1994 or IS 11166 : 1993 as the case may be shall apply.

10 FREEDOM FROM DEFECTS

10.1 All castings shall be free from defects that will adversely affect machining or utility of castings.

10.2 When necessary to remove risers or gates by flame or arc or a combination thereof, or by any other process involving intense heat, care shall be taken to make the cut at a sufficient distance from the body of the casting so as to prevent any defect being introduced into the casting due to local heating. Any such operation is to be done before final heat treatment.

10.3 In the event of any casting proving defective from foundry causes in the course of preparation, machining or erection, such casting may be rejected notwithstanding any previous certification of satisfactory testing and/or inspection.

11 FETTLING AND DRESSING

All castings shall be properly fettled and dressed, and all surfaces shall be thoroughly cleaned.

12 HEAT TREATMENT

12.1 The castings shall be heat-treated in a properly constructed furnace, having adequate means of temperature control which shall permit the whole of the castings being uniformly heated to the necessary temperature. All castings shall be suitably heat treated so as to attain the specified mechanical properties.

12.2 Castings shall be given a homogenisation heat treatment in accordance with 12.3 at the manufacturer's option or when specified by the purchaser in the enquiry and order, prior to solution heat treatment.

12.3 Homogenisation heat treatment when given shall consist of heating the castings and test material to a minimum of 1 050°C, holding for a minimum of 1.5 h, and cooling to ambient temperature.

12.4 All castings whether homogenised or not shall be given a solution treatment in accordance with 12.5 and unless ordered in the solution heat treated condition shall be precipitation hardened to one of the condition shown in Table 2.

12.5 Solution heat treatment shall consist of heating the casting and test material to 1 050±30°C holding at the rate of 1 h per 25 mm of section but not less than 1 h and cooling to ambient temperature.

12.6 Temperature used for precipitation hardening shall be maintained within a range of ±15°C of that listed in Table 2 for the heat treatment ordered.

12.7 Unless otherwise specified at the time of enquiry and order, the castings shall be supplied in the condition T 480, except as provided in 12.8. (see Table 2).

Table 2 Precipitation Hardening Heat Treatment

(Clauses 8.4.4, 12.4, 12.6 and 12.7)

Condition	Precipitation Hardening Temperature °C	Time in Hours Min	Cooling Treatment
S	Not precipitation hardened, but supplied in solution heat treated condition		
T 480	480	1.5	Air cool
T 495	495	1.5	„
T 550	550	4.0	„
T 580	580	4.0	„
T 595	595	4.0	„
T 620	620	4.0	„

12.8 When a minimum niobium content is specified in enquiry and order, the minimum precipitation hardening temperature shall be 495°C.

12.9 The test pieces shall be heat treated along with the castings they represent.

13 MECHANICAL TESTS

13.1 The mechanical properties specified are those which are to be obtained from test bars cast either separately from or attached to the castings to which they refer and heat treated as given in 12. The test values so exhibited, therefore, represent the quality of steel from which the castings have been poured; they do

not necessarily represent the properties of the castings themselves.

13.2 The tensile test shall be carried out in accordance with IS 1608 : 1972. The relevant mechanical properties shall be as given in Table 3.

13.3 The hardness test shall be carried out in accordance with IS 1500 : 1983, and requirements shall conform to those given in Table 3.

13.4 When investment castings are ordered, the sample shall be cast as shown in Fig. 1 and the tensile test piece shall be prepared as shown in Fig. 2.

Table 3 Mechanical Properties
(Clause 13.2)

Grade	Precipitation Hardening Heat Treatment	Hardness HB Min	Yield Stress 0.2 % Proof Stress, Min MPa	Tensile Strength Min, MPa	Elongation Percent, Min on 50 mm Gauge Length
1	T 480	375	1 000	1 170	5
	T 495	375	1 035	1 205	5
	T 550	311	965	1 035	9
	T 580	277	795	1 000	9
	T 595	269	760	930	9
	T 620	269	670	860	10
2	T 480	375	1 000	1 170	5
	T 495	375	1 035	1 205	5
	T 550	311	965	1 035	9
	T 580	277	795	1 000	9
	T 595	269	760	930	9
	T 620	269	670	860	10

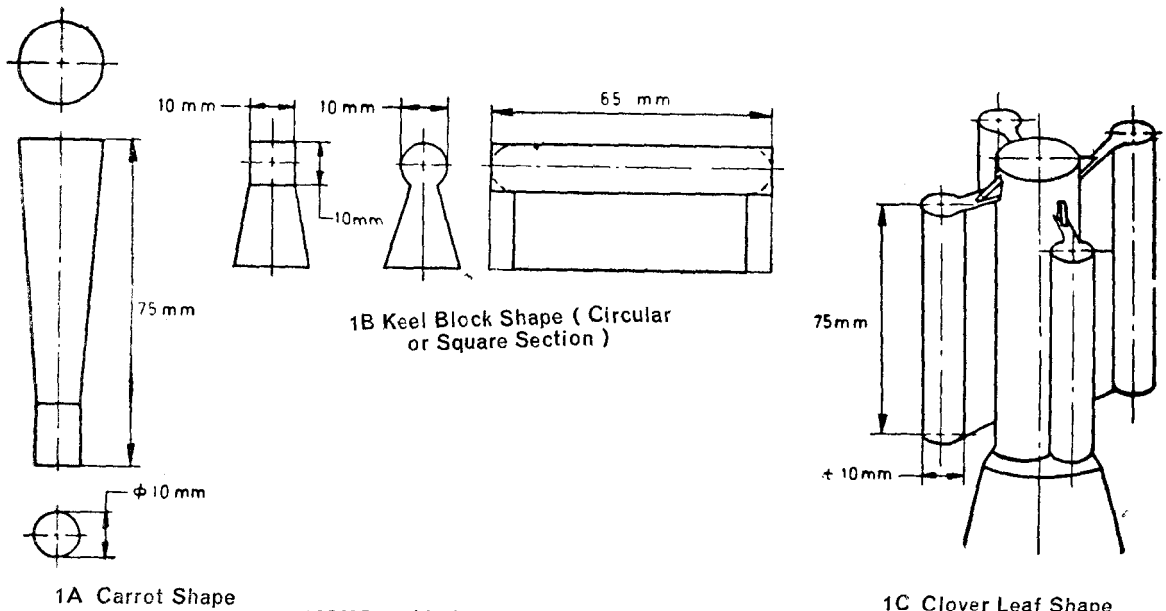


FIG. 1 TYPES OF CAST TEST SAMPLES

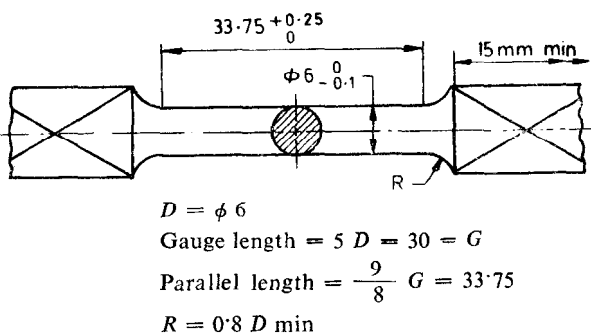


FIG. 2 TENSILE TEST PIECE

13.5 Unless otherwise specified at the time of enquiry and order, the castings shall be supplied in the condition *T 480*.

14 NON-DESTRUCTIVE TESTS

14.1 Non-destructive testing shall be applied if specified in the enquiry and the order. Under this heading are grouped the tests, which aim at revealing defects which cannot be revealed by a simple visual examination, such as penetrant, magnetic particle, ultrasonic, X-radiographic, or gamma-radiographic inspection; also included under this heading are tests on the surface condition by visual or visual-tactile examination. The purchaser shall specify in the enquiry and order:

- The type of non-destructive testing which he intends to carry out or to have carried out;
- The area or areas of the castings to which these tests apply, and the types of discontinuity, where relevant;
- Whether all, or what proportion, of the castings are to be tested;
- The severity level defining the acceptability or non-acceptability or defects which may be revealed; and
- Whether the manufacturer is or is not contractually responsible for carrying out the tests.

14.2 Unless otherwise agreed upon, when non-destructive testing is to be done, the castings shall be examined as follows:

- Ultrasonic examination as per IS 7666 : 1988,
- Magnetic particle examination as per IS 3703 : 1980,
- Liquid penetrant examination as per IS 3658 : 1981, and
- Radiographic examination as per IS 2595 : 1978.

14.3 Unless otherwise agreed upon the following shall be the acceptance standards:

- IS 9565 : 1986 for ultrasonic inspection,
- IS 10724 : 1988 for magnetic particle inspection,
- IS 11732 : 1986 for liquid penetrant inspection, and
- IS 12938 : 1990 for radiographic inspection.

NOTE — In case of austenitic grades, ultrasonic and magnetic particle examination would not ordinarily be feasible.

15 REPAIR OF CASTINGS

15.1 Unless otherwise specified by the purchaser in the enquiry and order, castings may be rectified by welding. All repairs by welding shall be carried out in accordance with the procedure laid down in IS 5530 : 1987. If castings have been subjected to non-destructive or hydraulic testing by agreement between the purchaser and the manufacturer, the castings shall be re-examined in the area of repair following any rectifying operation performed on the castings.

15.2 To form the basis of an agreement between the purchaser and the supplier in this respect where relevant, the following classification shall apply concerning the extent of repair:

- Weld repair involving a depth not exceeding 20 percent of wall thickness or 25 mm, whichever is lower, shall be termed as a minor repair.
- Any weld repair exceeding the above shall be termed as a major repair. Further any single repair having an area exceeding 250 mm square for every millimetre of wall thickness shall also be deemed to be a major repair, regardless of the considerations mentioned in (a) above.

15.3 Weld repairs shall be made only in the homogenized, solution treated or *T 595* condition.

15.4 Castings welded in the *T 595* condition shall be post-weld stress relieved by holding at 580°C for minimum of $1\frac{1}{2}$ hours. If the final heat treatment requires precipitation hardening at temperature lower than 580°C, the welded casting shall be re-solution heat treated and precipitation hardened at the specified temperature after welding.

15.5 The welding procedure to be followed for any welding that may be required on surface hardened area, if any, shall be as agreed to.

16 METHOD OF SAMPLING

The method of sampling the steel castings for the purpose of chemical analysis and mechanical tests including re-test shall be in accordance with IS 6907 : 1992.

17 MARKING

17.1 Each casting shall be legibly and indelibly marked with the following:

- a) The number of identification mark by which it is possible to trace the melt and the heat-treatment batch from which it was made;
- b) The manufacturer's initials or trade-mark; and
- c) Other identification marks in accordance with any agreement between the purchaser and the manufacturer.

NOTE — It is recommended that a minimum of marking be used.

17.2 By agreement between the purchaser and the manufacturer, castings complying with the requirements of this standard may, after inspection, be legibly marked with an acceptance mark.

17.3 The castings may also be marked with the Standard Mark.

17.3.1 The use of Standard Mark is governed by the provisions of Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to the manufacturers or the producers may be obtained from the Bureau of Indian Standards.

ANNEX A

(Clause 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	Title	IS No.	Title
228 :	Methods for chemical analysis of steels (<i>second revision</i>)	7666 : 1988	Recommended procedure for ultrasonic examination of ferritic castings of carbon and low alloy steel (<i>first revision</i>)
1500 : 1983	Methods for Brinell hardness test for metallic materials (<i>second revision</i>)	8800 : 1986	Technical delivery conditions for steel castings (<i>second revision</i>)
1608 : 1972	Methods for tensile testing of steel products (<i>first revision</i>)	9565 : 1986	Acceptance standards for ultrasonic inspection of steel casting (<i>first revision</i>)
2595 : 1978	Code of practice for radiographic testing (<i>first revision</i>)	10724 : 1988	Acceptance standards for magnetic particle inspection of steel castings (<i>first revision</i>)
3658 : 1981	Code of practice for liquid penetrant flaw detection (<i>first revision</i>)	11166 : 1993	Permissible deviations on dimensions, surface roughness and mass of steel castings made with investment castings process (<i>first revision</i>)
3703 : 1980	Code of practice for magnetic particle flaw detection (<i>second revision</i>)	11709 : 1986	Technical delivery conditions for investment castings of steel
4897 : 1994	Deviations for untoleranced dimensions and mass of steel castings (<i>third revision</i>)	11732 : 1986	Acceptance standards for dye penetrant inspection of steel castings
5530 : 1987	Code of procedure for repair and rectification of steel castings by metal arc welding process (<i>first revision</i>)	12938 : 1990	Acceptance standards for radiographic inspection of steel castings
6601 : 1987	Permissible deviations in chemical composition for products analysis of steel castings (<i>first revision</i>)		
6907 : 1992	Methods of sampling steel castings (<i>first revision</i>)		

ANNEX B

(*Clause 7*)

INFORMATION TO BE SUPPLIED BY THE PURCHASER

B-1 BASIS FOR ORDER

While placing an order for the purchase of steel castings covered by this standard, the purchaser should specify the following:

- a) Material specification;
- b) Drawing or reference number of the pattern (if supplied by the purchaser), along with a copy of the drawing;
- c) Optional/Additional tests required, if any;
- d) Whether the castings are to be inspected and tested in the presence of the purchaser's representative;
- e) Condition of delivery;
- f) Any special requirement; and
- g) Test report, if required.

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Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition.

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Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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